

Inorganic Nomenclature

Chemistry is a lot like living in a foreign country. If you speak the language, life is more fun! Learning inorganic nomenclature is the first step toward learning the language of chemistry. Learning the relationship between chemical formulas and chemical names is essential for understanding chemical problems. Inorganic nomenclature is a systematic way of naming the thousands of inorganic compounds we encounter.

Your textbook discusses nomenclature of inorganic compounds. This handout is intended to supplement and complement your book Chapter 7.

There are certain elements, cations, and anions that you **MUST** know before you get started. Position in the periodic table can help you remember many, but not all. For any name you should be able to write the formula and for any formula you should be able to write the name including spelling.

1. You should know the first 38 elements and Au, U, Ag, Sn, Hg, Cd, Sb, I, Xe, Cs, Ba, Rn, Ra, and Pb

2. Compounds with common names:

| | | |
|-------------------------------|---|-------------------|
| H ₂ O | - | water |
| H ₂ O ₂ | - | hydrogen peroxide |
| NH ₃ | - | ammonia |

3. Cations

Names

Lithium ion, sodium ion, etc.
Beryllium ion, magnesium ion, etc.
Hydronium ion
Aluminum ion
Iron(II), Iron(III)
Copper(I), Copper(II)
Silver ion
Mercury(I), Mercury(II)
Lead(II), Lead(IV)
Ammonium ion
Cadmium ion
Zinc ion
Nickel(II), Nickel(IV)
Gold(I), Gold(III)
Cobalt(II), Cobalt(III)
Tin(II), Tin(IV)
Chromium(II), Chromium(III)

Symbols

Li⁺, Na⁺, K⁺, Rb⁺, Cs⁺
Be²⁺, Mg²⁺, Ca²⁺, Sr²⁺, Ba²⁺
H⁺
Al³⁺
Fe²⁺, Fe³⁺
Cu⁺, Cu²⁺
Ag⁺
Hg₂²⁺, Hg²⁺
Pb²⁺, Pb⁴⁺
NH₄⁺
Cd²⁺
Zn²⁺
Ni²⁺, Ni⁴⁺
Au⁺, Au³⁺
Co²⁺, Co³⁺
Sn²⁺, Sn⁴⁺
Cr²⁺, Cr³⁺

4. Common Monatomic Anions

| <u>Name</u> | <u>Symbol</u> | <u>Name</u> | <u>Symbol</u> | <u>Name</u> | <u>Symbol</u> |
|-------------|-----------------|-------------|------------------|-------------|------------------|
| Hydride | H ⁻ | Iodide | I ⁻ | Telluride | Te ²⁻ |
| Fluoride | F ⁻ | Oxide | O ²⁻ | Nitride | N ³⁻ |
| Chloride | Cl ⁻ | Sulfide | S ²⁻ | Phosphide | P ³⁻ |
| Bromide | Br ⁻ | Selenide | Se ²⁻ | Arsenide | As ³⁻ |

5. Common Polyatomic Anions (two or more atoms)

| <u>Name</u> | <u>Formula</u> | <u>Name</u> | <u>Formula</u> | <u>Name</u> | <u>Formula</u> |
|--------------|---|-------------|--------------------------------|--------------|---|
| Nitrate | NO ₃ ⁻ | Sulfate | SO ₄ ²⁻ | Nitrite | NO ₂ ⁻ |
| Permanganate | MnO ₄ ⁻ | Carbonate | CO ₃ ²⁻ | Dichromate | Cr ₂ O ₇ ²⁻ |
| Hydroxide | OH ⁻ | Chromate | CrO ₄ ²⁻ | Sulfite | SO ₃ ²⁻ |
| Cyanide | CN ⁻ | Phosphate | PO ₄ ³⁻ | Chlorite | ClO ₂ ⁻ |
| Perchlorate | ClO ₄ ⁻ | Peroxide | O ₂ ²⁻ | Hypochlorite | ClO ⁻ |
| Thiocyanate | SCN ⁻ | Chlorate | ClO ₃ ⁻ | Acetate | C ₂ H ₃ O ₂ ⁻ |
| Bicarbonate | HCO ₃ ⁻ | Bisulfate | HSO ₄ ⁻ | Arsenate | AsO ₄ ³⁻ |
| Oxalate | C ₂ O ₄ ²⁻ | Bromate | BrO ₃ ⁻ | Formate | HCO ₂ ⁻ |

6. Acids

| | | | | | |
|--------------|--------------------------------|-------------|-------------------|--------------|-------------------|
| Sulfuric | H ₂ SO ₄ | Perchloric | HClO ₄ | Hydrocyanic | HCN |
| Phosphoric | H ₃ PO ₄ | Chloric | HClO ₃ | Chlorous | HClO ₂ |
| Nitric | HNO ₃ | Hydrobromic | HBr | Hypochlorous | HClO |
| Hydrochloric | HCl | Hydroiodic | HI | Nitrous | HNO ₂ |

7. Bases

| | | | |
|---------------------|------|---------------------|---------------------|
| Lithium hydroxide | LiOH | Magnesium hydroxide | Mg(OH) ₂ |
| Sodium hydroxide | NaOH | Calcium hydroxide | Ca(OH) ₂ |
| Potassium hydroxide | KOH | Strontium hydroxide | Sr(OH) ₂ |
| Cesium hydroxide | CsOH | Ammonia | NH ₃ |
| Rubidium hydroxide | RbOH | | |

There are four main classes of inorganic compounds we will learn how to name:

1. Compounds made from single valence metals.
2. Compounds made from multivalent metals.
3. Compounds containing only nonmetallic elements.
4. Acids (next semester)

Nomenclature Rules

Nomenclature is a set or system of names. The nomenclature that is used in chemistry is based on the IUPAC (International Union of Pure and Applied Chemists) convention. The basic rule is that the name of a particular compound must be completely unambiguous – that is, one name means one particular compound and no other. The simplified rules that follow can be used to name the majority of inorganic compounds.

Rules For Nomenclature Of Simple Compounds

Rule 1

The names of ionic compounds are derived from the positive ions (cation, usually a metal) and the negative ions (anion, non metal) in the compound.

For nonionic compounds (covalent/ molecular), consider the compound to be composed of 2 parts, one positive and one negative.

Rule 2

The positive ion or part is always named first and written first in formulas. The basic rule: if an element is to the left of another element in the periodic table or below it, it is always less electronegative and named or written first.

Rule 3

Binary Compounds (2 elements only)

- (a) Positive element with a fixed oxidation state (metal or hydrogen):
- | | | |
|--------------------------|---|-----------------------------------|
| Cation | | Anion |
| Name of positive element | + | “negative stem” with –ide suffix. |
- e.g. CaCl_2 calcium chloride
- (b) Positive element with a variable oxidation state (metal): **Stock System** where the oxidation number of a metal(usually a transition metal) is specified with a Roman numeral in parenthesis and the negative ion is named as in (a) above. Old Method stem name of metal (usually Latin) with the –ic indicating higher oxidation number and –ous the lower.
- e.g. CuCl copper (I) chloride or cuprous chloride
 CuCl_2 copper (II) chloride or cupric chloride
- (c) Two Nonmetals: named as illustrated in (a) with prefixes to indicate how many of each element is present. EXCEPTION: if the first element consists of only one atom, the prefix for it is assumed (leave out -mono).
- e.g. CO carbon monoxide
 N_2O_3 dinitrogen trioxide

| | |
|--------|---|
| mono- | 1 (omitted if no other prefixes are used) |
| di- | 2 |
| tri- | 3 |
| tetra- | 4 |
| penta- | 5 |
| hexa- | 6 |
| hepta- | 7 |
| octa- | 8 |
| nona- | 9 |
| deca- | 10 |

- (d) In general, the -ide ending means binary compounds.

Exceptions:

| | |
|--------------------------|--|
| NH_4Cl | ammonium chloride (ammonium salts) |
| $\text{Mg}(\text{OH})_2$ | magnesium hydroxide (metal hydroxides) |
| CuCN | copper (I) cyanide (metal cyanides) |

- (e) Binary Acids: i.e. hydrogen plus a nonmetal

In gas phase, named as in (a):

| | |
|------------------|-------------------|
| HCl (g) | hydrogen chloride |
|------------------|-------------------|

In water solution:

| | |
|-------------------|--|
| HCl (aq) | hydro (prefix) + negative stem + -ic acid hydrochloric acid |
|-------------------|--|

Rule 4

Other Compounds: compounds composed of three (or more) elements, most commonly a metal ion or hydrogen combined with a polyatomic ion (a non-metal, or occasionally a transition metal, combined with oxygen, as a general rule). Generally, it is best to memorize the polyatomic ions, along with their charges. With a few exceptions, all end in -ate or -ite. Compounds composed of metals plus these polyatomic ions are named as in (a) or (b) above, except that the name of the polyatomic ion is used in place of the nonmetallic ion. (The names and formulas of various polyatomic ions are given on your "Oxidation Numbers of Some Common Ions Sheet" sheet.

| | | | |
|------|------------------------------------|----------------------|-------------------|
| e.g. | $\text{NaC}_2\text{H}_3\text{O}_2$ | sodium acetate | |
| | $\text{Cu}(\text{BrO}_3)_2$ | copper (II) bromate | or cupric bromate |
| | $\text{Ni}(\text{NO}_3)_3$ | nickel (III) nitrate | |
| | $(\text{NH}_4)_2\text{SO}_4$ | ammonium sulfate | |

Rule 5

Acids: When the polyatomic ion is combined with hydrogen, the compound is named as an acid

When the anion does **Not** contain Oxygen:

Use the prefix *hydro* + root of the anion's name - *ic* + the word acid Examples: HCl - hydrochloric acid; HBr - hydrobromic acid

When the anion contains Oxygen:

The name will depend on the name of the polyatomic anion. DO NOT use the prefix hydro.

Examples: H_2SO_4 the anion is sulfate, therefore the acid name will end in ic – Sulfuric acid.

H_2SO_3 the anion is sulfite, therefore the name of the acid will end in ous – sulfurous acid.

- ate → "ic"

- ite → "ous"

Warm up

| Compound | Cation | Anion | Formula |
|------------------------|--------|-------|--|
| calcium phosphate | | | |
| potassium nitrate | | | |
| ammonium sulfate | | | |
| aluminum hydroxide | | | |
| rubidium peroxide | | | |
| lithium hydride | | | |
| calcium nitride | | | |
| ammonium nitrate | | | |
| nickel(III) sulfate | | | |
| barium nitrite | | | |
| chromium(II) phosphate | | | |
| | | | BPO ₃ |
| | | | Ba(ClO ₂) ₂ |
| | | | CsC ₂ H ₃ O ₂ |
| | | | Si(MnO ₄) ₄ |
| | | | K ₃ AsO ₄ |

Nomenclature Practice

Metallic Compounds

- | | |
|---------------------------------------|---|
| 1. _____ chromium (III) chloride | 2. _____ gallium phosphate |
| 3. _____ copper (I) sulfate | 4. _____ barium acetate |
| 5. _____ strontium hydrogen carbonate | 6. _____ calcium nitride |
| 7. _____ potassium chromate | 8. _____ magnesium carbonate |
| 9. _____ strontium dichromate | 10. _____ ammonium phosphate |
| 11. _____ | $\text{Al}_2(\text{SO}_4)_3$ |
| 12. _____ | AuCl_3 |
| 13. _____ | $\text{Ca}(\text{C}_2\text{H}_3\text{O}_2)_2$ |
| 14. _____ | K_3AsO_4 |
| 15. _____ | CuSO_3 |
| 16. _____ | Cs_2HPO_4 |
| 17. _____ | $\text{Zn}(\text{BrO}_3)_2$ |
| 18. _____ | $(\text{NH}_4)_2\text{CO}_3$ |
| 19. _____ | BeSO_4 |
| 20. _____ | FeO |

Nonmetal Metallic Compounds

- | | |
|------------------------------------|------------------------------|
| 21. _____ PBr_3 | 22. _____ CF_4 |
| 23. _____ SO_3 | 24. _____ CO_2 |
| 25. _____ N_2O | 26. _____ IF_5 |
| 27. _____ SbCl_3 | 28. _____ SiO_2 |
| 29. _____ BrF_5 | 30. _____ SiC |
| 31. _____ tetraphosphorus decoxide | 32. _____ diarsenic trioxide |

- | | |
|-----------------------------------|------------------------------------|
| 33. _____ carbon tetrachloride | 34. _____ carbon monoxide |
| 35. _____ phosphorus pentabromide | 36. _____ bromine dioxide |
| 37. _____ carbon monosulfide | 38. _____ phosphorus pentachloride |
| 39. _____ dinitrogen tetroxide | 40. _____ tellurium dioxide |

Mixed Review

- | | |
|--------------------------------|--|
| 41. _____ tin (IV) oxide | 42. _____ zinc permanganate |
| 43. _____ ammonium hydroxide | 44. _____ silver nitrate |
| 45. _____ iron (II) dichromate | 46. _____ silver bicarbonate |
| 47. _____ hydrogen formate | 48. _____ nitrogen triiodide |
| 49. _____ boron trifluoride | 50. _____ hydrocyanic acid |
| 51. _____ sulfuric acid | 52. _____ $\text{Au}_3(\text{PO}_4)_2$ |
| 53. _____ CuHSO_4 | 54. _____ BI_3 |
| 55. _____ FeCl_3 | |

MORE Mixed Review

- | | |
|----------------------------------|-------------------------------|
| 56. _____ FeAsO_4 | 57. _____ Arsenous acid |
| 58. _____ copper (II) oxalate | 59. _____ potassium iodate |
| 60. _____ ammonium dichromate | 61. _____ magnesium peroxide |
| 62. _____ gold (II) cyanide | 63. _____ potassium hydroxide |
| 64. _____ lead (IV) oxide | 65. _____ tungsten (IV) oxide |
| 66. _____ palladium (II) cyanide | 67. _____ BF_3 |
| 68. _____ NH_4I | 69. _____ CoCl_3 |
| 70. _____ NO_3 | 71. _____ FeAsO_3 |
| 72. _____ mercury (II) cyanide | 73. _____ HBrO_2 |
| 74. _____ HClO_3 | 75. _____ lead (II) acetate |

